What we need to know & learn

Laszlo Petho, PhD, CPEng, RPEQ
Principal researcher
ARRB Brisbane
• Full depth asphalt thicknesses in excess of 400 mm in QLD
• There is a need to reduce the thickness of heavy duty asphalt pavements
• This can be achieved through higher performances; i.e. higher stiffness or better fatigue resistance (or both), while not compromising rutting resistance, moisture sensitivity and overall pavement performance
• Enrobés à Module Elevé (EME) – High modulus asphalt can be a cost effective answer
• EME class 2 (EME2) is not ‘only’ a material – it is a concept
• EME2 – fully performance based mix design, which is directly connected to a general mechanistic procedure (GMP) for pavement design in France
• EME2 will be referenced as EME in this presentation
Pavement model - example

80 kN single axle dual tyres

Weighted Mean Annual Pavement Temperature - WMAPT

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (mm)</th>
<th>1st Modulus (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OG14</td>
<td>40</td>
<td>E₁ = 800 MPa</td>
</tr>
<tr>
<td>DG14</td>
<td>50</td>
<td>E₂ = 1650 MPa</td>
</tr>
<tr>
<td>DG20</td>
<td>365</td>
<td>E₃ = 2900 MPa</td>
</tr>
</tbody>
</table>

εᵥ, εₜ
Fatigue performance
Asphalt materials behave differently

\[
y = 2465.6x^{-0.131} \\
R^2 = 0.8049
\]
\[
y = 3036.4x^{-0.163} \\
R^2 = 0.948
\]

\(\varepsilon_6 = 319 \, \mu\text{strain}\)

\(\varepsilon_6 = 404 \, \mu\text{strain}\)
Real pavement temperatures
Cullen Ave West, Eagle Farm, QLD

![Graph showing pavement temperatures over time.](image)

- Real pavement temperatures
- Cullen Ave West, Eagle Farm, QLD

**Legend**
- 6:00
- 9:00
- 12:00
- 15:00
- 18:00
- 21:00

**Dates**
- 14 March 2014
- 21 February 2014
EME projects in Australia

<table>
<thead>
<tr>
<th>Implementation phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Exploratory study - preliminary laboratory test results.</td>
</tr>
<tr>
<td>L Petho, E Denneman, EME Technology Transfer to Australia: An Explorative Study,</td>
</tr>
<tr>
<td>AP-T249-13</td>
</tr>
<tr>
<td>• Selection of equivalent Australian test methods and tentative specification limits.</td>
</tr>
<tr>
<td>• Structural pavement design, including trial setup and field validation.</td>
</tr>
<tr>
<td>• Cooperation with major asphalt and bitumen suppliers and AAPA.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Austroads TT1353 (completed).</td>
</tr>
<tr>
<td>• Austroads TT1908 (in progress).</td>
</tr>
<tr>
<td>• TMR P9 (in progress).</td>
</tr>
</tbody>
</table>
Objectives of the works
Austroads & TMR

• Clarify the function of EME in typical Queensland pavement designs – CONCEPT
• Collect information about the performance parameters (workability, moisture sensitivity, rutting resistance, stiffness, fatigue resistance) of EME – MIX DESIGN
• Understand the stiffness of EME at different temperatures and loading conditions for QLD – MIX/PAVEMENT DESIGN
• Develop guidelines for the design of heavily-trafficked pavement structures containing EME - PAVEMENT DESIGN
Objectives of the trial

Construction and production

- Production control and variability
- Are low in situ air voids achievable?
- Material response and compaction curve under Australian compaction equipment
- Different thicknesses/compactibility
- Temporary trafficking – is gritting necessary?
- Amount of tack coat on top of EME

Benchmarking/mix design specification

- In situ material performance validation
- Input into mix design/benchmarking/development of tentative specification levels

Pavement design

- In situ pavement performance/pavement design case studies
- Long term monitoring, development of shift factors for design
- Validating realistic design input values (stiffness/fatigue)
- Pavement instrumentation (strain response validation/temperature correction; input into many other projects)
Pavement instrumentation for validating the design an ongoing performance monitoring

- Weather station funded by AAPA and implemented by ARRB
- The financial contribution from AAPA towards this project is greatly appreciated
- Weather Maestro weather station, manufactured by Environdata, Warwick
- Air temperature sensor, solar radiation sensor, wind, evaporation and six pavement temperature sensors (20-40-80-160-260-360 mm depth)
- Solar power, and remote access via Next G
- Collects data from strain gauges
EME Demonstration project in Q

EME Class2 mix

Volumetric properties

DG20HM mix
EME2
GB 1
GB 2 & 3
BBSG

Note: GB3 similar to DG20HM
Source: Delorme, J, Roche, C & Wendling, L 2007, LPC bituminous mixtures design guide, Laboratoire Central des Ponts et Chaussees, Paris, France
Calculation example – QLD demonstration trial

At the time of the pavement design the following assumptions were made:

- DG10 1800 MPa
- DG20HM 2360 MPa
- EME 5400 MPa

Initial notes

- Design is sometimes controlled by subgrade and not asphalt criteria
- The gap in stiffness may be slightly smaller between DG20HM and EME – there is a laboratory program in progress
- Design properties of the thin wearing course will also be validated
Calculation example – QLD demonstration trial

Pavement thickness according to the Australian method
(using the Shell fatigue equation)
Wearing course: 30 mm DG10 asphalt

<table>
<thead>
<tr>
<th>Subgrade property</th>
<th>EME thickness (mm)</th>
<th>DG 20 HM thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR 5%</td>
<td>110</td>
<td>160</td>
</tr>
<tr>
<td>CBR 10%</td>
<td>80</td>
<td>130</td>
</tr>
<tr>
<td>CBR 15%</td>
<td>70</td>
<td>110</td>
</tr>
</tbody>
</table>

Pavement thickness according to the French method
Wearing course: 30 mm DG10 asphalt.

<table>
<thead>
<tr>
<th>Support category</th>
<th>EME thickness (mm)</th>
<th>GB3 thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF2 (CBR 5%)</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>PF2q (CBR 10%)</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>PF3 (CBR 15%)</td>
<td>70</td>
<td>100</td>
</tr>
</tbody>
</table>
Pavement and air temperatures
Cullen Avenue West, Eagle Farm, QLD
Strategic Alliance Workshop

EME Demonstration project in Q

What we need to know & learn - Petho

Strain response under an empty front end loader

Values for demonstration only as strain gauges are not interfaced yet
FWD test parameters

• Load: 50 kN on asphalt, 40 kN on granular base
• Wheel path/between wheel paths
• 10 metres, staggered
• FWD test on the asphalt base on 17 February 2014 (morning)
• Surface temperatures 37.6 – 44.9 °C
• FWD data is not temperature corrected
Air temperatures at the time of the trial

Source: www.bom.gov.au - location 040842 Brisbane Airport (2.1 km away)
Surface modulus – Eastbound traffic lane
On unbound granular layer (prior to paving)
On asphalt base layer (prior to opening to traffic)
Surface modulus – Westbound traffic lane
On unbound granular layer (prior to paving)
On asphalt base layer (prior to opening to traffic)
The way forward

Monitoring the trial section at Cullen Ave West, Eagle Farm

- Measuring strain responses at known pavement temperatures and loading – input into design validation
- Ongoing FWD measurement at known pavement temperatures – capturing seasonal variation
- Monitoring pavement behaviour with different subgrade bearing capacity
- Back-calculation of in situ properties – cross validate with laboratory results
- Monitor functional performance, i.e. rutting, IRI and surface texture by using the network survey vehicle (NSV)
- Review performance in the light of pavement design and as built properties - we know everything about the pavement structure and the materials

(Hopefully) active contribution to the NSW trial, Gerringong, Princes Hwy

- Install strain gauges, pavement temperature sensors and weather station – financial assistance from AAPA
- Monitor production and construction during the trial and include outcomes into the report
- Ongoing functional and structural performance monitoring under highway traffic
The success of the trial resulted from the collective efforts of every organisation involved

- Boral Asphalt
- SAMI Bitumen
- Brisbane City Council
- AAPA
- TMR
- ARRB project team: Andrew Beecroft, Johnathon Griffin, Erik Denneman
- Special thanks to Xavier Guyot, Technical Manager, COLAS OI-AA-O for his continuous support and help with mix design and pavement design related issues
Summary

EME
- Technology transfer
- Including mix design and pavement design

Validation
- Extensive laboratory testing
- Pavement design case studies
- Production and demonstration trials

Benefit
- Reduction in pavement thickness
- Long term structural performance
- BUT careful implementation is needed
Strategic Alliance Workshop
EME Demonstration project in Q

What we need to know & learn - Petho